INSTITUTION NOTES

July, 1941

Annual Institution Luncheon.

The Annual Luncheon of the Institution will be held on Friday, September 26, 1941 at Grosvenor House, Park Lane, London. Members are requested to make a note of the date. It is expected that the function will be the most important of the kind yet held by the Institution.

Lecture Fixture.

Mr. Mark Taylor (member) will read his paper on "Some Applications of Optics to Engineering" to the Birmingham Section on Wednesday, July 23, 1941 at 7-0 p.m., James Watt Memorial Institute.

Honour for Yorkshire Section President.

Captain C. W. Mustill (member), President of the Yorkshire Section, Works Director of Jackson's Boilers, Ltd., Holbeck, Leeds, has been awarded the M.B.E.

Annual Election to Council—Official Notice.

NOTICE IS HEREBY GIVEN of an election to fill eight vacancies amongst the Ordinary Members of Council. The Councillors retiring by rotation, who are eligible for re-election, are Messrs. J. W. Berry, T. Fraser, E. W. Hancock, M.B.E., J. A. Hannay, F. A. Pucknell, J. R. Sinclair, and I. H. Wright. Dr. H. Schofield, M.B.E, co-opted since the last Annual Election, also retires and is eligible for re-election.

Candidates for election (who must be Honorary Members or Ordinary Members) must be nominated, in writing, by three Ordinary Members or Associate Members, except that retiring Councillors willing to stand for re-election do not require nomination. Each Section Committee may nominate one candidate.

Nominations should be forwarded to me at the offices of the Institution, 36, Portman Square, London, W.1. The latest date for receiving nominations is Monday, August 18, 1941.

July 17, 1941. R. HAZLETON, *General Secretary*.

Section Presidents for 1941-42.

Birmingham Section—J. W Berry.
Coventry Section—J. A. Boyes.
Cornish Section—J. G. Young.
Eastern Counties Section—F. C. Laws.
Edinburgh—R. D. Ewart.
Glasgow—I. Garvie, B.Sc.
Leicester and District Section—J. R. Gimson.
London Section—J. Blackshaw.
Luton, Bedford and District Section—R. Broomhead.
Manchester Section—Major T. M. Barlow.
North Eastern Section—W. A. Harriman, M.B E.
Nottingham Section—H. J. Gibbons.
Preston Section—R. D. G. Ryder.
Sheffield Section—J. W. Walker.
Southern Section—J. F. W. Butler.
Sydney (N.S.W.) Section—C. G. Crane.
Western Section—J. T. Kenworthy.
Yorkshire Section—Capt. C. W. Mustill, M.B.E.

Graduate Section Chairmen, 1941-42.

Birmingham Graduate Section—W. A. Robinson.
Coventry Graduate Section—F. Cotton.
London Graduate Section—A. C. Pike.
Loughborough College Student Centre—Dr. H. Schofield, M.B.E.

Meeting of the Council.

The Council met at Manchester on June 20, 1941. Members present were Mr. G. E. Bailey, C.B.E., President; Mr. N. V. Kipping, Chairman of Council; Mr. J. D. Scaife, Past-President; Dr. H. Schofield M.B.E., Major Barlow, and Messrs. J. W. Berry, J. H Bingham, J. A. Boyes, D. Burgess, A. W. Davies, W. F. Dormer, H. A. Drane, T. Fraser, H. J. Gibbons, G. H. Hales, H. A. Hartley, B. C. Jenkins, J. T. Kenworthy, H. le Cheminant, W. Puckey, F. A. Pucknell, R. D. G. Ryder, and F. Williams. Also present, Messrs. F. W. Cranmer, P. V. Lord and T. A. Stoddart (Manchester Section Committee), Mr. R. G. Ryder (Hon. Secretary,

Preston Section), Mr. R. Hayleton (General Secretary). and Miss Larbalestier (Office Manager).

Prior to the meeting, the Council was entertained to luncheon at Messrs. Metropolitan-Vickers' works. Mr. G. S. Maginness, President of the Machine Tool Trades Association, attended the luncheon, by invitation, and replied cordially to the welcome extended to him by the President of the Institution.

Subscriptions for Research Department.

Subscriptions towards the work of the Institution's Research Department have been received within the past few weeks from the following :—

	£	s.	d.
Austin Motor Co. Ltd.	250	0	0
British Thomson-Houston Co. Ltd.	250	0	0
English Steel Corporation	250	0	0
Thos. Firth and John Brown, Ltd.	250	0	0
Metropolitan Vickers Electrical Co. Ltd.	250	0	0
The Associated Equipment Co. Ltd.	100	0	0
Vauxhall Motors, Ltd.	100	0	0
David Brown & Sons, Ltd.	50	0	0
B.S.A. Tools, Ltd.	50	0	0
George Bray, Ltd.	50	0	0
Leyland Motors, Ltd.	50	0	0
John Lund, Ltd.	26	5	0
Mollart Engineering Co. Ltd.	26	5	0
Hepworth & Grandage, Ltd.	25	0	0
N. Davis (Associate Member)	0	10	6

Firm's Subscriptions to Research Department to be Treated as a Trade Expense.

The Institution has made an arrangement with the Inland Revenue under which subscriptions from firms to the work of the Research Department can be treated as a trade expense by contributory firms. Donations of a capital character, or for specifically capital expenditure, do not come within the scope of the agreement.

F.B.I. Production Committee.

Mr. J. D Scaife (Past-President) has been appointed a member of the new Production Committee of the Federation of British industries. Mr. N. V. Kipping (Chairman of Council and of the War Emergency Committee), as announced last month, is also a member of the Committee. The F.B.I. has nominated representatives to serve on the proposed Advisory Committee to the Production Executive of the Cabinet.

National Certificate in Production Engineering for Scotland.

At a meeting n Glasgow on July 2, 1941, there was set up a Joint Committee representing the Institution of Mechanical Engineers, the Institution of Production Engineers, and the Scottish Education Department to establish a Scheme for the award of Higher National Certificates in Production Engineering in Scotland. The Joint Committee will also deal with Ordinary National Certificates in Mechanical Engineering with sufficient Production Engineering content to make them eligible for countersignature on behalf of the Institution of Production Engineers.

Mr. I. Garvie, B.Sc., President of the Glasgow Section, and Mr. T. White, Past-President, Glasgow Section, have been appointed by the Council to represent the I.P.E. on the Joint Committee, and were present at the meeting. The General Secretary was also present.

Newly Elected Members.

Members :

D. H. ALEXANDER—College of Technology, Belfast.
W. H. BOWEN—Sigmund Pumps (Gt. Britain) Ltd., Gateshead.
C. C. BOWMAN—Harland & Wolff, Aircraft Dept., Belfast.
E. B. GIBSON—Sigmund Pumps (Gt. Britain) Ltd., Gateshead.
J. MCNEILL—North Road Loco. Works, Darlington.
J. JEX-LONG—A. Reyrolle & Co. Ltd., Hebburn-on-Tyne.

Associate :

J. D. URQUHART—Short & Harland, Ltd., Belfast (M.A.P.).

Associate Members :

J. D. COOK—Laurence, Scott & Electromotors, Manchester.
C. HADDEN—Simpkin Engineering Co. Ltd., Gedling, Notts.

Associate Members—contd.

H. V. LEWIN—Metal Castings, Ltd., Worcester.

A. A. NICOD—A. Reyrolle & Co., Hebburn-on-Tyne.

W. G. NICOD—A. Reyrolle & Co., Hebburn-on-Tyne.

C. RHODES—A. Reyrolle & Co., Hebburn-on-Tyne.

T. S. ROCHESTER—Sir W. G. Armstrong Whitworth & Co., Ltd., Gateshead.

S. W. SHAW—Melchett Road Factory Centre, Birmingham.

E. R. TAYLOR—A. Reyrolle & Co., Hebburn-on-Tyne.

R. W. WELLS—Ashmore, Benson, Pease & Co. Ltd., Stockton-on-Tees.

A. WOODHEAD—Forgrove Machinery Co. Ltd., Leeds.

Intermediate Associate Members:

W. BRAY—Herbert Morris, Ltd., Loughborough.

J. CUTHILL—Aeronautical Inspection Dept., Belfast District Office.

H. S. PROPSTING—Gilbert & Barker Manufacturing Co. (Australia) Pty. Ltd., N.S.W.

R.J.A. REID—Metropolitan-Vickers Electrical Co. Ltd., Manchester.

F. H. WESTON—Birmingham Central Technical College, Birmingham.

E. W. WILSON—Gilbert & Barker Manufacturing Co (Australia) Pty. Ltd., N.S.W.

Graduates:

E. DIXON—Harrison Knitting & Textile Machinery Co. Ltd., Manchester.

W. E. JEFFRIES—A. Reyrolle & Co. Ltd., Hebburn-on-Tyne.

N. F. KIRBY—Loughborough College, Leicester.

C. S. KNOTT—A. Reyrolle & Co., Hebburn-on-Tyne.

J. R. SWANN—Short & Harland, Ltd., Belfast.

J. J. WILSON—Rubery Owen Messier, Warrington.

Students:

D. E. FAULKNER—74, Markby Road, Winson Green, Birmingham.

H. J. RICHARDS—Mount Cottage, 69, Shale Street, Bilston.

F. N. SHORTMAN—377, Birmingham Road, Walsall, Staffs.

Affiliated Firm:

ASSOCIATED BRITISH MACHINE TOOL MAKERS, LTD., Calcutta, India.
Affiliate: STANLEY WAGGETT, General Manager

Transfers.

From Graduate to Associate Member:

A. E. RILEY.

From Graduate to Intermediate Associate Member:

A. E. GROOCOCK.

From Studen · to Graduate:

V. J. L. WHITLEY.

Posts of National Importance: Central Register.

The Ministry of Labour and National Service (Central Register Branch) is finding it increasingly difficult to satisfy the requirements of Government Departments and industry for suitably qualified candidates for posts of national importance. Will any member who feels that his release can be arranged for work of greater national importance please send full details of his case to—

B. J. TAMS, Esq., M.Sc., A.M.I.Mech.E.,
Ministry of Labour and National Service,
Central Register Branch,
Queen Anne's Chambers,
Tothill Street,
London, S.W.1.

THE DESIRABILITY OF ACCEPTANCE TEST CHARTS FOR MACHINE TOOLS

A JOINT meeting of the Institution of Production Engineers and the Institution of Mechanical Engineers was held at the Institution of Mechanical Engineers (London) on October 25, 1940, at 2-30 p.m., for a discussion on "The Desirability of Acceptance Test Charts for Machine Tools." Mr. W. A. STANIER (Vice-President, Institution of Mechanical Engineers) presided. "Acceptance Test Charts for Machine Tools, Part I," prepared by the Research Department of the Institution of Production Engineers and published jointly by the two Institutions in March, 1940, formed the basis for the discussion.

MR. STANIER (Chairman) said that although present circumstances made it difficult to secure a full discussion, it would be good to ventilate opinions and endeavour to crystallise the views of manufacturers and engineers interested in the subject.

MR. MARK H. TAYLOR, M.I.P.E., in opening the discussion, paid a tribute to the work of the late Mr. H. C. Armitage, M.I.P.E., who had collected many valuable data which formed the basis of the acceptance test charts under discussion. Mr. Armitage had made a close study of the acceptance methods proposed by Colonel Salmon and by Dr. Schlesinger. He had added the results of his own experience, and had led the Research Committee of the Institution of Production Engineers in preparing a set of charts which it was believed retained the best features of the contributions from all three sources.

The charts had been the subject of criticism. Some said that the tolerances suggested were too fine, but the more frequent criticism was that they were far coarser than the tolerances to which the better machine tool makers at present inspected their products. The charts were not intended to do more than assure a minimum standard of accuracy in the installed machine. Where a machine tool fell well within the prescribed tolerances it was a most welcome addition to the plant. The greater accuracy there was in the machine the more margin had the operator, the less time would he take to do his work, and the less would be the skill required.

Probably, further charts would be introduced later for precision machinery, but the fact that the first charts did not legislate for anything but the minimum acceptable standard did not condemn them as of no value.

The existing charts probably needed some modifications in detail, but the present occasion was not the right time to discuss whether a given tolerance on a particular feature of a machine tool was too large or too small. The important point was to decide whether charts of this type were desirable and useful.

When an engineer employed a machine tool on a manufacturing process, he was generally demanding a standard of accuracy on the product which it was not easy for unskilled labour to achieve. Broadly speaking, it was true to say that if the required standard of accuracy was easily achieved by a machine, unskilled labour could be employed. From that it followed that, particularly at times like the present, it was most desirable that the machine tool should be of a prescribed accuracy if maximum output was to be obtained.

So much for the individual machine. Where a shop contained a large number of machines of nominally equal capacity but possibly of different makes, another very important consideration must be satisfield. Unless all the machines in a group satisfied the prescribed standard, the person responsible for keeping the machines loaded was continually seeking simple low-accuracy jobs to put on the least accurate machines, and in general, while the accurate machines were overloaded the less accurate ones were slack.

In many highly organised shops the loading of machines was not done by the foreman but by a progress office, working from theoretical data for the production of a given part by a machine of a given capacity. When all the machines of a group did not reach the prescribed standard, the foreman was obliged to ignore the layout and re-allocate the work to those machines which were in a fit condition to receive the work. That alone might be enough to discredit the progress office and even the management.

At the present time particularly manufacturers had to utilise any machine tools that they could find. It was false economy to install machines of unknown accuracy. A machine tool had to be made right only once, but unorthodox methods had to be applied to every piece produced if the machine was inaccurate. The user therefore required the simplest possible means of determining that a machine tool installed in his works was in a proper condition to produce an accurate product without requiring any special "dodges" on the part of the operator. The desire for such a check did not in any way imply that all machine tools were inaccurately produced; one could generally depend upon the products of a reputable manufacturer.

The defects present in a machine tool as installed in the user's works might be due to a number of causes. The machine might have been inaccurate when it was sent from the maker's works; it

might have been damaged or strained in transit; and, most common of all, it might have been improperly installed. He would have thought that machine tool manufacturers would welcome a commonly understood technique of assuring that their products were properly installed.

The real question, then, was how best to check the condition of the installed machine. If it was assumed, as it generally could be, that the machine as it left the maker's factory was satisfactory, means had to be provided by which the purchaser could check his machine as installed and make sure not only that it would produce one or two simple test pieces accurately, but that it was in a fit condition to produce any piece within its capacity.

The first thing to do was to ensure that the machine was properly levelled and that it was properly supported so that it was not in a strained condition. That was provided for in the charts under the heading of "Levelling." Next came a series of tests designed to ensure that each important assembled unit of the machine was in correct relationship to the base or table of the machine. It was on the necessity for that check that most of the argument arose.

It was very frequently stated that all the user needed to know was that the machine would do its job. That was true if by "job" one meant all the jobs that the machine could reasonably be called upon to do. The reason why a machine could not be tested adequately merely by machining a particular workpiece in it was that no single job, and not even a small number of jobs, could test all combinations of functions of which a machine was capable. It was true that a practical test was necessary to check rigidity, freedom from chatter, finish and the like (and those were provided for in the charts), but to check a machine by a practical test for all the combinations of functions of which it was capable was actually a far more lengthy process than to test it geometrically and then make a practical test to check all those features which a geometric test could not cover. Taking a lathe as example, the spindle might be out of parallel with the ways on the bed, the tailstock might be similarly inaccurately located and the cross slide might not be square to the ways of the bed, but the lathe might still be capable of turning parallel work between centres. It might even face a shoulder accurately when the piece was held in the chuck, but it would soon fail on some other combination of functions.

The mistaken conception that a complicated group of elements could be checked by inspecting one combination of them was very common; thus it was often assumed that all the nominally interchangeable components of an assembly were correct if one set of them, chosen at random, could be assembled. In practice such a check only showed that one particular set of components would go

together. It did not give the slightest proof that all parts in the batch were interchangeable. A satisfactory check could be achieved only if components representing extreme dimensions (top and bottom limits) would enter into an assembly with equal facility. If that was so, then all the components could be regarded as interchangeable.

Taking a sample test piece on a machine tool, one test piece would provide evidence only that a given set of dimensions was correctly co-related. *Plus* errors in certain features might cancel *minus* errors in other features. All that could be judged from a single test piece was that the combination of its particular dimensions was satisfactory.

It was true that a small proportion of machine tools was designed for the repetition of certain simple components, possibly those machines could be tested by checking their capacity to produce accurate components, but most machine tools were purchased for use on a large but unknown variety of operations falling anywhere within their capacity. It was generally impossible for the purchaser to say exactly what the machine was to be used for, and, even if he could, the machine tool manufacturer would then have to satisfy different conditions for every purchaser.

Machine tool manufacturers who were sure that their products could easily pass the prescribed tests had nothing to fear but praise, for there was no proposal to undo all their good work. They had much to gain by educating the machine tool user so that he installed his machines properly and became more discriminating and more capable of knowing when he had a really good machine.

The use of the charts, however, was not confined to new machines. The argument that all machines in a group must be of a prescribed standard applied throughout the life of the machines. It was only too common for a machine to be relegated to less and less accurate work, until it had to be taken out for overhaul because it would no longer produce good work. All that time it would have been a worry to the operators and a cause of inefficiency. In more enlightened works machines were inspected at regular intervals, whether there had been a complaint about them or not. The charts provided an excellent basis for that inspection, and, what was more, they provided a first-class basis for overhaul. Each unit could be repaired and assembled to the limits prescribed by the charts, and the whole group could be kept up continuously to a condition in which it was giving maximum production.

From his application of the charts, not as a machine tool builder but as a user, he submitted that they were of the utmost value. There never had been a time, except perhaps during the last war, when they could have been of greater value, for it was now necessary

to re-enlist every old machine and to install every new machine that could be obtained, whether it was the product of a reputable machine tool maker or the product of a concern that had never made machine tools before but wished to help the national effort, or whether it came from the opportunist who thought that any sort of so-called machine tool would find a buyer at the present time. All those products had to be put to work by unskilled labour. If output was to be obtained under such circumstances, the machines must pass to a given standard, and that standard was provided by the charts under discussion, as those who had applied them would testify.

THE CHAIRMAN said that when many of those present served their apprenticeships they knew very little about tolerances, and, although they knew that such a thing as a thousandth of an inch existed, they did not know how to measure it. The skilled turner of those days knew how to obtain a press fit for certain sizes, and it was by his own personal experience that he obtained the assembly and the finish required. Engineers had now got beyond that stage, but even in many engineering establishments their machine tools were put down by a mechanic who thought that when his spirit level gave an accurate reading he had done all that was required. On one occasion his company put in some heavy duty wheel lathes. The old wheel lathes drove the wheels through a post in the spokes of the wheels, and it did not matter whether the face plates were parallel or not, but in heavy-duty lathes each wheel was chucked to the face plate, and it made a considerable difference if the face plates were not parallel. When the new lathes were put down he told the millwright's foreman that before the work was grouted up he would like to see it. He obtained a tubular micrometer sufficiently long to go between the face plates, and he took a measurement on the four quarters of the face plate; then he turned the face plates through a quarter of a revolution and took the measurements again. He told the foreman that the bed was out of level; the foreman indignantly said that he had levelled it with a spirit level and it could not be moved any more, as it was 30 in. deep. He suggested to the foreman that he should put some wedges down the centre rib of the bed, and, when this had been done, he found to his astonishment that the face plates had become absolutely parallel. Only by the introduction of means for measuring accurately to thousandths was it possible to check the alignment of the machine in that way.

He had heard it suggested in some quarters that machines could not be designed from the Acceptance Test Charts. In his view those charts were not meant to be used for the designing of machine tools. The question whether a machine was able to do the job within its capacity was an entirely different proposition. But the

charts provided a system which had been tried very much more on the Continent than in this country, and which should enable machine tool makers and users to have a very valuable indication as to whether the machine would work within the limits required.

MR. J. D. SCAIFE, M.I.P.E., said he had read more into the terms of reference than the question of the desirability of acceptance tests. He thought it was a question of the desirability of national acceptance tests, because, so far as he could gather, there was not much argument from any quarter about the desirability of acceptance tests; most makers had tests of their own. The question which had been discussed in the country a little while ago was whether the matter should be dealt with in the normal way by the British Standards Institution, and it was from that point of view that he had considered the subject.

It appeared that the advantages to be gained by building machine tools to a recognized national system of alignment tests were almost entirely in favour of such a procedure, and indeed it was difficult to discover a logical argument in support of individual and independent practice with no relationship to a basic standard. From the manufacturer's point of view there was no doubt that the adoption by him of an approved system of alignment tests almost invariably enforced such improved manufacturing methods that improved economy as well as quality resulted. Systematic examination of the elements of a machine for static accuracy during the course of erection exposed inferior machines and equipment, as well as bad machining, as nothing else would; and the natural result was that good quality and quantity were found together. From the point of view of the user, either at home or abroad, it was a distinct source of satisfaction to have the maker's certificate that the machine he had purchased had passed a prescribed test of accuracy, and makers who were prepared to issue such certificates would undoubtedly be given a preference. Goodwill and a reputation for good quality were fine things to possess, but both were too unreliable for an overseas buyer who was out of touch with current events at home. Changes in policy, through whatever cause, could rapidly undermine the quality of a firm's product, and a user who bought on reputation could be seriously disappointed in consequence. On the other hand, manufacturing skill was no longer the monopoly of guilds and family concerns, as it was at one time. It was quite possible for a new organization to come into being and in a short time, by reason of superior skill and endeavour, produce a product equal to the best. For such firms standards of comparison were necessary to enable users to have their products immediately available for purchase on their merits.

If, then, it was to the advantage of both maker and user to recognize an individual firm's system, the advantage to the trade as a whole should be the greater if makers and users could get together and set their seal on national standard acceptance tests. German machine tool makers had been forced to prepare such standard tests when they began to do business with Russia on a large scale. One firm was "played off" against another to such an extent that business became impossible until Dr. Schlesinger was called in to prepare standards acceptable to both parties. Incidentally, that work had had considerable effect on the expansion of the machine tool trade and armaments production of Germany

The experience of British manufacturers had been somewhat similar in its need for national standards, but, in the absence of co-operative action by the Machine Tool Trades Association, individuals had had to fight their own expensive battles with the U.S.S.R. British machine tool makers, however, as a body were intensely individualistic; there was something peculiar about the nature of the trade which developed such a characteristic, and it was extremely unlikely that the machine tool industry would, on its own initiative, examine the subject sufficiently broadly to recognize the possible advantages to themselves, apart from the advantages to the engineering industry. The most influential makers still retained the same outlook on standardization that had always characterized the individual interest as against the general welfare of industry at large. The engineering industry at one time opposed Whitworth in his efforts to standardize screws for precisely the same reason which now dominated the machine tool trade, namely, a short-sighted policy of trade protection.

Speaking generally, the objection to national standards came from those members of the industry who were capable of working to any reasonable standard of accuracy and who already had good standards of their own, so that it could not be claimed that the objects were based on technical difficulties. Indeed, it was a well-established fact that high-class machine tools could not be made in quantity by old-fashioned methods, but must be constructed under a rigid system of inspection based on close accuracy as a first principle of manufacturing economy.

The root of the influential opposition to national standard alignment tests lay, he believed, in the fear that such standards, if accepted by the trade, would lay a well-defined track to their markets at home and abroad, which would be used by the weaker members to the disadvantage of the larger manufacturers. Those who adopted that attitude failed to recognize that the export trade suffered generally due to the lack of an accepted yardstick in the hands of overseas buyers.

In his opinion the whole outlook on standardization was wrong, not only in the particular province of the subject under review but generally, in that too much domination by manufacturing interests was permitted and too little by users' interests. There was a wealth of meaning in such well-accepted truths as "He who pays the piper calls the tune," and "The customer is always right"; and, whilst influential people payed lip service to such expressions, it was not desired that the customer should presume too much on his rights. It was sufficient for him to weigh up values of material and reputation and then "take it or leave it."

The question whether there should or should not be national standard alignment tests in Great Britain was surely one for the general body of machine tool users to settle for themselves, and The Institution of Mechanical Engineers and The Institution of Production Engineers were quite competent, within their own ranks, not only to call for such standards, but to prepare and publish them. Members of the two Institutions would know that a joint body representing both Institutions had been engaged in preparing standard acceptance tests for some years. The practice of representative machine tool makers had been examined by experienced engineers and machine tool makers in order to provide a sound basis for the standard acceptance tests. When the present heavy demand for machine tools lessened, the voice of machine tool users would once more become articulate, and it would be found, when the makers and users got together for the purpose of preparing national acceptance tests, that there was little additional work to do.

Judging from his own experience, both as a user and as a maker of machine tools, he was satisfied that it would be an unquestionable advantage to the user of machine tools to know that the machines he bought were made to some nationally accepted standard of accuracy. He also considered that standard acceptance tests prepared by those representing the interests of users, with or without the assistance of the machine tool trade, should have sufficient standing to be regarded as national standards. The attitude of the industry which was represented by the leading members and which had been supported by responsible Government opinion was that, whatever the merits or demerits of the national alignment standards might be, the present time was not opportune for the matter to be examined. On the face of it that argument appeared to be quite sound, but actually no greater fallacy could be imagined. Never before in the history of this country had there been such a demand for machine tools, and, on account of the assistance which had had to be rendered by non-professional machine tool firms, there had never been so great a need for national standards of accuracy as now. The demand for Dr. Schlesinger's

recently translated book had shown the extent of the need, which should have been met by an official British Standard.

MR. J. E. BATY, M.I.P.E., observed that it appeared to him that machine tool tests and alignments had to come at some date, and it was only a matter of whether they came now or later. How the members would decide the question which was then before them would depend upon whether they were reformers or reactionaries. Dr. Schlesinger, in presenting his paper* before the Institution of Mechanical Engineers in 1938 concluded with the following words: "The tendency of most buying departments is to buy on a price basis. Imagine the position of a salesman offering a good, soundly designed and constructed machine in competition with another, which in general appearance and specification appears the same, but which in fact is perhaps half the price and worth less. Fixed standards of manufacture would enable a quick comparison to be made and the higher-priced machine justified by difference of quality. Some firms appear to have no idea what is meant by limits of accuracy, and this makes standard limits of accuracy absolutely essential. The good makers would benefit, because the inferior makers would either have to increase their price and work to a better standard or go out of business. . . . The slight extra cost of instituting a simple and effective inspection system in the works will be more than offset by the saving in ultimate rectification. It will be found that by adhering to such tests very much better results will ultimately be obtained at lower cost. Moreover, by introducing such tests the manufacturer has a safeguard against fancy limits imposed by foreign inspectors."

In times like the present, when so many firms were starting for the first time to make machine tools, it seemed to him to be absolutely essential for such firms to have something like the Acceptance Test Charts. The charts would also help the production engineer to understand just what accuracy he might expect from any particular class of machine tool.

Again, standard tests and alignments would enable stan dard testing equipment to be designed. The British Standards Institution had been assisting by standardizing such testing equipment as spirit levels, straight-edges, squares, surface plates, dial gauges, and so forth, all of which were used in the inspection of machine tools. The National Physical Laboratory had carried out work on the development of methods of testing, and Messrs. Taylor, Taylor and Hobson had also designed special equipment for the same purpose. Dr. Schlesinger had been working in other directions, one of which was testing the mandrels used for testing machine tools,

* *Proc. I. Mech. E., 1939, Vol. 138, p. 59.*

and he would shortly be publishing those tests. It would, therefore, be seen that when standardization of the kind in question was started, it immediately gave rise to a complete investigation into the tools and methods used by other engineers, and so the whole matter was put on to a much sounder basis.

If the test and alignments in question could be compiled as a British Standard Specification they would immediately be circulated in Australia, New Zealand, South Africa, and Canada as an automatic part of the British Standard Institution's procedure, and in all probability they would be adopted as standards by those countries. It was known that India and South America were anxious to obtain goods from this country on British Standard Specifications.

Finally, specifications such as were under discussion at the present meeting would show to the world that the British machine tool industry was alive to the needs of the times.

MR. C. LE MAISTRE, C.B.E. (Director, British Standards Institution) said that he had had the privilege of listening to so many discussions such as the present one that he felt he knew all the arguments for and against the standardization of machine tool tests. It was extremely difficult to bring forward any new argument, as the whole ground had apparently been covered. On the present occasion he had not heard any arguments against standardization, such as he had listened to on previous occasions.

The British Standards Institution provided a neutral platform on which the manufacturers on one side and the users on the other could ventilate their opinions and then come together. Unfortunately, the producers of machine tools were not yet prepared to come to that neutral ground with the users. From the commencement of the work of the Engineering Standards Committee in 1901 the principle had been adopted that the Committee would not go forward unless the producers and the users agreed that it was advisable to do so. The British Standards Institution was therefore waiting for the time, which he hoped would not be long distant, when the question would be reopened and the committees which had been formed would resume their work. It might not be generally known that the British Standards Institution had been asked to begin the work of standardizing machine tool tests and had had half a dozen sub-committees working on the subject, but suddenly the war had come and all the work had had to be stopped.

He wished to say a few words on the export side of the matter. At the present moment the British Standards Institution was compiling a handbook in Spanish on British industrial practice. It was being splendidly supported throughout the export industry of the country, and the British Standards Institution had the help

of the British Council and the blessing of the Foreign Office and the whole of the Export Council of the Board of Trade in the compilation of the book, which would be a unique means of informing South Americans of the immense progress being made by British industry. It was frequently said in South America that Britain was right behind and the Americans were far in front in industry, which was not true. The handbook would show South Americans that was not true. He had not yet solved the problem of what was to be said in the book with regard to machine tools; he thought it might be necessary to have two articles, one from the manufacturers and one from the users. If they did not agree he did not think that either party could object to the other putting in an article setting out their point of view. He hoped, however, that agreement might be obtained to an article which would show the progress that was being made.

He believed that manufacturers sometimes said that the Americans had no national agreements on machine tools and therefore there was no need for such agreements in this country, but surely it would be better to say: "The Americans have not any such agreements; let us go ahead and get them." Export trade would then be obtained by this country, because South Americans were very pro-British at the moment, and it would be very advantageous to be able to tell them that agreement had been reached in this country and that they would be perfectly safe in basing their requirements on British National Standards.

Mr. A. Powis Bale, A.M.I.Mech.E., remarked that he was at one time employed by a large organization of machine tool makers, consisting of nine or 10 firms, which could not agree amongst themselves on any details of standardization of accuracy. The accuracy of the products of the different makers in the group varied immensely, yet they sold their products through a common subsidiary company, both on the Continent and in England. The materials were sound and the machines were good, but there were great differences in the methods of manufacture and in the checking of the accuracy of the machines. If such a state of affairs could occur in a composite body, what was going to occur among all the unrelated machine tool makers? He thought it was absolutely necessary to proceed with the standardization of accuracy, and the present seemed a very good time for that work to be done. The user played a very important part in the matter; the Government was now a very large buyer and user, and if the right people were in the Department concerned some progress might be made in the matter.

Mr. Le Maistre said that he was very interested in Mr. Taylor's remarks about the difference between the geometric tests and the performance tests. In general standardization the British Standards

Institution had based its work more and more on performance, wherever it was possible to do so, and he was surprised to hear that production engineers did not favour the idea of basing their alignments on production tests. It seemed to him that what the user wanted to know was that the product of the machine was in accordance with certain tolerances. The geometric tests were certainly most valuable and, in fact, essential in questions relating to maintenance. With regard to acceptance tests, he asked why it was not possible to accept, as Colonel Salmon and French makers had done, the principle of the test being carried out on the actual product.

MR. TAYLOR observed that the real difficulty in accepting a machine tool solely in terms of a product was that, generally speaking, a machine tool was a universal device which could carry out an immense variety of operations. One could, of course, test a machine tool by carrying out a series of jobs which would test all its functions, but that would generally be so lengthy a task that it would be far better to apply a series of geometric tests, together with one or two simple practical tests to deal with the features not covered by a geometric test. It was not right to suggest that a machine could not be tested by its product; the point was, he thought, that it would take too long to turn out a sufficiently large variety of products.

MR. L. ST. L. PENDRED, C.B.E., M.I.Mech.E. (past-President, I. Mech.E.), said that he thought that Mr. Taylor's remarks would apply particularly to the general purpose machine.

MR. TAYLOR said that the common machine tools, such as the lathe, the milling machine, the grinding machine, and the surface, cylindrical, and internal boring machines, were universal machines. He could quite conceive that a machine producing only one type of product (e.g. a simple automatic machine producing small screws), would in many respects be far better tested by practical tests, and the alignment test might not be necessary.

MR. LE MAISTRE asked whether it would not be possible to devise a sample work-piece that would cover the major functions of a general-purpose machine.

MR. TAYLOR replied that that might not be impossible, but so far as his experience went it could not be done easily. He would welcome any suggestion for a simple test device suitable for any universal machine. He would thoroughly enjoy the task of attempting to prove that it was impracticable.

MR. G. W. CLARKE, M.I.P.E., speaking as a buyer of machine tools, thought that most of those present knew that, given sufficient skill and time, it was quite possible to produce a good job on a machine that was itself inaccurate. A man who bought machine tools made an investment in the means to do a job; machine tools

were not bought to stand idle while skilled setters carried out tricks to get them to produce accurate work. The value of the investment depended on the proportion of its time that a machine tool could do good work, and if the machine which was purchased was a good machine it should be reasonably accurate in all its alignments so that it could work over the full range of duties of which it was supposed to be capable.

When he bought electrical machinery he could specify exactly what he required and was able to get exactly what he wanted; surely machine tool buyers should also be in that position. Users did not wish to dictate to the machine tool maker how he should build his tools or how he should set out his machine operations. But it was for them to say exactly what accuracy they expected to get, and that was common to so many industries that he failed to see what objections could be taken to it. So far as he could see, the simple tests outlined in the charts did not interfere in any way with the makers, but only gave the limits between which the machine should be aligned.

MR. H. CRITCHLEY asked how long the machine should be capable of maintaining the limits laid down. It was well known that the suitability of the material and the finish largely determined how long it would be before measurable wear took place, but such considerations did not seem to be mentioned in reference to the limits in the charts. The difference between many a good machine and many a poor machine was revealed only after they had been in use for a short time. A cheap material could be used and the limits could be tested on that job with rough surfaces, and for a short time it would conform to certain limits, but when wear took place, due to the use of inferior material, adherence to the limits vanished.

MR. F. TURNER, M.I.Mech. E., remarked no speaker had yet said whether it was proposed to accept the idea that the alignment test should be carried out at the maker's works or whether the user should insist, as he himself hoped he would, that the alignment test should take place at his works, after the machine was finally in position. He would go still further and insist that the machine should be tried to its full capacity, and even an overload capacity, and should be run for a period up to a month before the final alignment tests were taken. Alignment tests taken immediately the machine was completed, before it had been run in, might be misleading.

It seemed reasonable that there should be not only an alignment test, but also a production test; he did not think they should be regarded as alternatives, but he considered that, after the alignment test, which gave an indication of capacity, a production test should be carried out.

MR. G. H. HALES, M.I.P.E., said he thought that some difficulty might arise from the machine tool manufacturer's point of view,

in taking alignment tests and production tests after a machine had been installed for a month. There was a possibility that it would place on the machine tool manufacturer the very grave onus that the machine had been installed correctly and properly. He recalled a case in which a firm of high repute had made a machine which would have passed the tests for alignment on the charts under discussion. The machine was delivered to a works on the day the firm was closed for Christmas holidays; the weather was very bad, and the machine lay outside for some days before it was installed. When installed, it was found to be inaccurate; and it had distorted considerably. If the onus of taking alignment tests a month after the machine had been installed was placed on the manufacturer, he would probably have to charge considerably more for the machine.

If Dr. Salmon's test, i.e. testing the machine in production on a piece of material, was adopted, it would be quite possible, using a production workpiece, to get the accuracy required by using various artifices in setting up the machine. On the other hand there would be no difficulty to prevent a machine which had been passed on acceptance tests from doing equally well in production on Dr. Salmon's test. In the one case if a machine fulfilled the standard tests on alignment, results could be obtained; in the other case those results could indeed be obtained, but when another job was attempted the machine might well be inaccurate.

MR. SCAIFE asked whether Mr. Turner would like to submit a gun to a test a month after it had been fired.

MR. TURNER said he thought that that was not a parallel case. He also suggested that if a manufacturer thought his machine would produce accurate work for the first month only he would only have a low opinion of his machine. Overload tests were common; they were natural and necessary. He did not, of course, mean a very heavy overload; but taking a lathe for instance, the machine should be given the biggest piece that was to be turned, and then the biggest rough cut that was proposed should be taken. If the machine would not withstand those conditions it was obviously not a machine to buy.

MR. SCAIFE contended that his suggestion was perfectly analogous. A screw was not spoiled immediately it had suffered the slightest wear; when one tested the screw certain allowances were made, and the screw had a certain life. There was not necessarily a parallel between a test of a machine and an endurance test. A screw would wear and a machine would wear, but that was no argument for having a machine inaccurate at the outset. The same applied to a micrometer; it, too, would wear, but that again was no argument for not having it right at the beginning.

MR. CLARKE said that when purchasing machine tools he frequently specified that they should be inspected at the maker's

works and satisfy a severe test there before they were accepted and he had never yet found a machine tool maker who refused to submit to that condition.

MR. HALES said that he entirely agreed with Mr. Turner in asking for an overload test. It would not, of course, be practicable to take it a month after the machine had been installed.

MR. TAYLOR, referring to the question raised by Mr. Turner as to whether the tests should take place at the maker's or at the purchaser's works, said he thought that much of the controversy regarding the advantages of the tests arose on that point. The tests were a means whereby the purchaser could satisfy himself that, having installed his machine, it was in a fit condition to do its work. Many machine tool makers immediately jumped to the conclusion that the object of the alignment test charts was to prove that their products were not good, but that was not the object at all. If the machine was found not to be in a fit condition the reason might be that it had never been accurate; but the reason was much more likely to be that the machine had been strained in transit, and in 90% of the cases the reason was that the machine had not been properly installed. In other words the test was to a large extent a check by means of which the user could satisfy himself that the machine had been installed properly.

MR. V. GARTSIDE, M.I.P.E., said that it was not always possible to test machine tools by the products. Usually that could be done only in the customer's works, since in the maker's works many of the machines were not on a proper foundation, but were only resting on wedges.

The question of alignments had been raised many years ago, and then one of the objections of the machine tool makers had been that if the alignments were fixed, users would immediately conclude that *all* machine tools were to be made to those limits and tolerances. There were many engineering jobs in which such accurate tolerances were not at all necessary for machine tools. One would not work to five places of decimals when designing a wheelbarrow, and the same idea applied to machine tools to a certain extent, and that he thought was one reason why the Machine Tool Trades Association was rather afraid of the alignment tests. He did, however, think that there ought to be some alignment tests as a standard for reference, like the standards for gearing. Gears were classified into (1) commercial and (2) high-duty gears, and were graded into classes A, B, C, and D, according to the work that they had to do. To introduce such grades for machine tools would require a very elaborate system of tolerances, and it would not be easy to prepare a set of charts to suit every kind of machine tool. A set of standard alignments could, he thought, be introduced for standard machines (e.g. ordinary lathes, drilling machines, milling machines, etc.). When anything

better was required it should come into a different category for which a different standard would be required. If the Machine Tool Trades Association took that point of view he could not see why it should have such a strong objection to a standard alignment chart for standard machines.

Mr. Bale had referred to an organization consisting of nine or 10 firms, each of which produced machines to a different standard of alignment. He thought that the reason was probably that the machines made by the different firms were for different classes of work. One firm might be making watch lathes and another firm might be making wheel lathes; these did not require the same standard of alignment. Again, it might be argued that the alignment of a boring machine did not matter if a jig was used, and he agreed that a good jig would itself control the alignment, but if the boring machine was to be used for every job that came along, the alignments laid down in the charts would be required.

Dr. G. Schlesinger (Director, I.P.E. Research Department), referring to Mr. Le Maistre's remarks on performance tests, said that the acceptance test charts gave five performance tests for lathes—round turning chucking, parallel turning chucking, parallel turning between centres, facing, and screwing. The alignment tests and the practical tests had been considered, and those which were necessary had been chosen from all the possible tests that had been suggested, so that it was sufficient for a lathe to be tested by the performance tests given in the charts. The same applied to milling machines.

Mr. Taylor had observed that it would be a very lengthy business to test every function of a machine tool for which it was capable. At the present time he himself was working on a horizontal boring mill, one of the most complicated of machines, and the Salmon test took six days to break the piece prescribed. Who could, or would, pay for such a test?

Had the test charts themselves been tested and proved? Was there any experience to show whether they were good or not? Were the machines which passed the tests useful or not? He believed that Mr. Turner could answer that all the machines he had accepted by the test charts had fulfilled their purpose satisfactorily.

Mr. Turner had said that a machine tested under an overload ought to be as accurate as it was before. That, however, was a matter of design and not alignment. If the machine was bent and twisted by the overload, it was too weak. The individuality of the British maker should be respected, and it was not desirable to check or criticize the design by the alignment tests. The question was how many tests had been made to prove that the alignment tests in the charts were satisfactory. In his experience about 300,000 machine tools had been so tested and he had not heard of more than two or

three objections made by people who had accepted machines on the alignment tests and had had some rejections afterwards.

Before the charts were published the practice of other countries had been studied. He had visited about 16 American machine tool works in 1924 and found that they all tested alignments; some of them gave him the alignments, but others said that they were secret, and must not be published. In Great Britain about 35 works had been visited, and they all worked to certain alignments, but did not wish to have them standardized. Thirty works had been visited in France and also six in Japan, which accepted the Continental tests on alignments. It was not true that a machine could pass the alignment tests on the charts and yet be inaccurate.

His own opinion was that the Acceptance Test Charts provided a system of checking the accuracy of machine tools of different kinds made by any manufacturer in the country. If the elements of a machine ought to be standardized, their development must be so advanced that the design, material and workmanship formed (at a given moment) the most suitable construction. Maker and user must be in agreement that standardization was necessary, and then it would not take long to find the best solution of the problem. The Acceptance Test Charts for machine tools in permanent use on the Continent were based on those principles. They intentionally avoided any interference with the individuality of the machine tool designer and maker. They embodied a short abstract of the system which every careful maker employed in checking the assembled machine in his works, and they were made to avoid disputes between maker and user if the delivered machine was working in its place in the user's workshop. The charts were not intended for competition or business purposes. When he made the arrangements between the Russian Government and the German Machine Tool Trades Association he was not a business man, but a professor at a university, and he had no interest in making the conditions as easy as possible. He had interviewed 40 Russian inspectors, who had been laying down the finest possible tolerances in the special branch of work in question, tolerances so fine that if insisted upon the cost of the machines would have been prohibitive. It was foolish to pretend that a planing machine 20 ft. long could be made correct to 1/10,000th in.

The standardization bodies of the International Federation of National Standards Associations (I.S.A.) were to-day composed of machine tool makers only, reinforced by some machine tool specialists who devoted their lives to the study and development of machine tools. But the standards in actual use were not international; there were German, French, Russian, Japanese, and Scandinavian standards. Because the technical perfection of British machine tools was already far advanced, standardization of the acceptance

system could be undertaken in this country. The success of a suitable standardization would surely be of benefit to the nation. The user's demand was that the working accuracy of the machine tool should be guaranteed for all sizes of work-pieces within the limits of the British Standards Institution fits, without vibration marks on the surface. The fits and tolerances were the basis of interchangeability. Every development in connexion with tolerances for forty years had been in the direction of an increasing refinement from 0.0005 inch in 1900 to 0.0001 inch in 1940. That was particularly valid for the important transition fits (sliding, push, and tight fits) and the refinement in question showed the ever-growing development of manufacturing from selective to non-selective production.

With regard to the work of the committees dealing with the subject in this country, the conditions for elaborating the British Acceptance Test Charts were as follows: Do not touch the individuality of the designer; do not test components; do not have regard to the quality of the materials used, that being already considered in the ordinary delivery; find a system which checks the assembled machine, ready for work, without dismantling; concentrate the checking conditions on the essential points which secure good results for the whole range of the machine tools; do not worry the maker with additional operations; do not burden the user with additional expense; perform the checking work in the minimum time; and use only the simple inspection tools of the ordinary workshop.

That great problem could be tackled only if the acceptance tests were the same for maker and user, based, of course, on the maker's experience. Consequently the maker's conditions were carefully studied, discussed, condensed, and shaped in a practical form. The British, American, Continental, Russian, and Japanese experience had been gathered. The different checking systems, proved by several hundred thousand machine tools during twelve years' application, were then used, their advantages and disadvantages being carefully weighed.

The first proposal for a British standard, produced by the joint efforts of The Institutions of Mechanical Engineers and The Institution of Production Engineers, was now in the hands of the members. It was intended to secure throughout the whole British industry the watchword of the time: "Economy and high quality," and that applied also to export.

THE CHAIRMAN remarked that he did not think that any misapprehension existed regarding the practice of the best machine tool makers in this country; it was well known that all of them had standards. He himself had been responsible for purchasing machine tools in very large numbers and of very many kinds. He thought

that the Acceptance Test Charts made a very fine basis for consideration; the only important thing which they did not give was a standard of finish for the various parts. He saw advertisements in the technical papers in which some makers gave their limits of accuracy compared with Dr. Schlesinger's limits; other makers would give the limits that they expected from their standard test-piece. That showed that there was a need for some standardization of such important functions.

Communicated

MR. BERNARD H. BROWN, M.I.Mech.E., wrote that the question of Acceptance Test Charts should have been postponed until after the war. The British machine tool maker had not up to the present considered universal charts to be necessary, otherwise he would have taken the initiative. On the other hand, the machine tool user might also take similar initiative, but up to comparatively recently he had not thought it necessary; and he thought that this was the attitude of most users to-day. However, to discover the need, or otherwise, for such charts, it was necessary for all machine tool makers and users to come to an amicable decision, and that was not possible under present conditions.

Makers of the higher class of machine tool already had their own standpoints of precision, which generally speaking were high. Some of them used the inspection tests produced by Dr. Schlesinger some years ago, but whatever tests were used, the finished machine tools were of a high standard of precision. Other makers of machine tools who supplied the cheaper market were not able to work to such high limits because of the cost. Much of the work produced by machine tools did not require a high-class machine, and users could not afford to pay for machine tools built to the Acceptance Charts now suggested. Machine tools were built to the requirements of the users, and those wanting precision tools could obtain them; those requiring only cheaper tools could also obtain them, at the relative price which the work justified. Any user who wanted his machine tools built to a particular limit could obtain them, but most users did not ask for, or even require, any precise limit, as price entered very much into the question.

MR. F. A. LEMON, M.I.Mech.E., wrote that he considered that the Acceptance Test Charts for machine tools were desirable, and it had been his practice for a number of years when ordering machine tools to insist that the machines were to be built and subject to test to the Schlesinger limits, or limits within that range, before being accepted. Further, there had been occasions when machines had been rejected due to the test results not falling within the limits.

MAJOR F. L. WATSON, M.C., T.D., M.I.Mech.E., wrote that the charts appeared to involve three different ideas :—

(1) The adoption of standards of accuracy in the construction of the machine, advocated in the Introduction.

(2) The correct assembly and erection of the machine after transport to the user's works.

(3) The responsibility for the erection and proving of the machine.

The great improvement in the quality of German machine tools, bringing them, in some cases, up to the level of first-class British tools, which followed Dr. Schlesinger's missionary work in Germany, was well known. That the general adoption of standards of accuracy in Britain would tend to level up the cheaper makes, might also be admitted, and it might be that the best makers would be able to resist the temptation to level down to such standards, which, as pointed out by Mr. H. C. Armitage, were not so fine in tolerance as British first-grade machines. That statement agreed with his own experience. He first became acquainted with Dr. Schlesinger's test charts some years ago, when he was managing director of the old firm of Joshua Buckton & Co. He found that the limits observed in building lathes, planing machines, and boring machines were, in all cases finer than those shown in the test charts. Those limits however, were not embodied in any contract with the purchasers of the machines. They accepted the machine which satisfied his firm's standards. If a test were desired by the purchaser, it took the form of machining a specimen of work in the maker's shop and applying measurements to the finished job; and it was believed that that was the wholly satisfactory practice of most high-class British firms.

The acceptance of machine tools on the proposed standards applied in the purchaser's works, involved responsibility on the part of the maker, not only for building the machine, for which he was normally paid, but also for accurate erection after delivery. This meant that for his own protection the maker must send out with each machine a skilled erector, who was not only capable of seeing it correctly set to work, but also capable of detecting any inaccuracy in the purchaser's instruments and any vagaries in his methods. The cost of that service must be added to the price of the machine. In § 3 of the General Instructions on page 9 the sections (*a*), (*b*), (*c*), and (*d*) implied that extension of the maker's liability. On page 13 there was recognition of the necessary quality of the purchaser's instruments, which the machine tool maker had either to accept or to check at his own expense.

There remained the human element in the actual testing. This could be controlled reasonably well if the test was carried out in the maker's works, but it would put an absurd responsibility on an

erector working away from his own shop and without the support of his own foreman.

Against these disadvantages to the first-class maker it appeared that the adoption of the proposed standards might be expected to produce a general levelling up of the second or third grade machine tool. But it would also facilitate the practice of buying machine tools at the lowest price complying with the standard, thus making the selection of plant a job for a clerk and leaving the results for some unfortunate engineer to sort out. In other words, it was another step in the process of substituting the card index for the skill of the engineer.

If the system of Acceptance Test Charts should be ultimately adopted, it was to be hoped that all machine tool makers would insist upon acceptance or rejection at maker's works, and refuse the proposal to accept or reject at user's works. His own opinion might be summarized as follows :—

(1) The Acceptance Test Charts could be very useful to the second or third grade maker who wished to improve his standard of production.

(2) The best test for the satisfaction of the user was the so-called "practical test," consisting of the machining and measuring of a test bar or casting.

(3) The prooposal to apply the Acceptance Test Charts for acceptance at the purchaser's works was grossly unfair, since it endeavoured to hold the maker responsible for measurements taken by numerous individuals with elaborate sets of instruments on which he had no check and in circumstances which were outside his control.

MODERN MANUFACTURING METHODS IN PLASTIC MATERIALS.

Paper presented to the Institution, London Section, by A. G. Snell.

The paper is based on considerable experience of practice in Britain, on the Continent and in U.S.A., and special care has been taken to avoid material already covered in papers published in the June, 1938, issue of the Journal. The chief items covered include Phenol material and fabrication, extrusion of phenol and urea materials, acetate materials, laminated sheet material, moulds and plant. In the discussion reference is made to the use of plastics in motor car and aircraft construction.

AFTER I was asked to give this paper, your Secretary sent to me a copy of your *Journal*. I was perturbed to discover that three previous speakers had given papers on Plastics, having descriptions which were very close to my descriptions. This made my task very difficult and left me wondering, so that my outlook changed to one of deciding what to omit or what to include, which had not been previously dealt with.

In any industry, once it has become firmly established, developments worthy of mention tend to become less numerous and rapid growth gives way to stable acceptance. Scientists, chemists and engineers are still seeking to improve existing materials and to find new materials, but naturally the nearer perfection they attain the less they can show over a short space of time. The Industry generally, is seeking new applications for these materials and it is in this connection, I personally have been spending a great deal of my time.

Apart from development in this country, I have studied the plastic industry, and made visits to some of the well known people on the Continent and in the United States and I will try to-night, to deal with the most important of my observations. In doing so, I shall find it necessary to refresh your memory with some of the better known methods, in order to convey fully my meaning, and trust that you will forgive me, should I occasionally appear to under-estimate your knowledge on the subject.

I propose to deal with the subject under various headings and have decided that the different types of materials from the ideal division. I have, therefore, segregated my remarks under the following: (1) Phenol material and fabrication. (2) Transference mouldings. (3) Urea material and fabrication. (4) Extrusion of

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Phenol and Urea Materials. (5) Acetate materials. (6) Laminated sheet materials. (7) Moulds. (8) Plant.

Phenol Material and Fabrication.

Plastic materials have been in existence for a matter of some 75 years, but it was not until the commercial application of phenol commenced 30 years ago, that plastics could be said to have taken their place in industry. Materials made from phenol resin are undoubtedly the most used, and I feel I am correct in saying, that the electrical industry was the first group to grasp the possibilities of this material, as the material possessed excellent insulation properties and the electrical industry was in the position to use great quantities of articles. This factor helped the plastic industry to manufacture on a mass production basis, shapes which recently could only be made by expensive building up or carving from the solid in costly materials. Other industries followed, which helped the manufacturer of phenol materials to improve and further develop these materials. The decorative value of the material was quickly appreciated, and industry as a whole, began to realize the sales appeal of articles previously manufactured for their utility only, if they could be pleasing to the eye.

The price of raw materials in the early days limited the uses to which it could be applied, but with ever increasing demands, this corrected itself and to-day we find our materials competitive in some form or other with practically every known industrial material.

The foresight of those engaged in research and the demand by various industries for materials possessing qualities peculiar to their requirements, have resulted in the industry having at its disposal a very wide range of specialized materials, and to-day we can offer in the phenol class, mouldings which are heat resisting, acid resisting, alkali resisting, shock resisting, water resisting and mouldings which possess exceptional electrical properties. Many industries have now come to regard plastics not as an alternative material but as a necessity. We, in the plastic industry, cannot visualize the electrical industry without our mateials, the same applies to other industries and has in the past applied to the wireless industry. The demand for receiving sets a few years ago, could never have been met without a material, which could be readily manufactured into intricate shapes, and which at the same time provided the necessary insulation. The wireless industry in this country, has not now the appetite for plastic mouldings which it displayed in the past. This is not due to the displacement of plastics, but to the natural stabilizing of production. The production of radio cabinets in the United States is still a tremendous business and many thousands of tons of material are used in this connection each year.

The low weight, half that of aluminium, combined with the necessary strength and the quality to resist acids, has made phenol materials indispensible in the production of artificial silk. One of the chief applications in the artificial silk industry is the spinning pot, a sample of which I have here to-night. The spinning pots are permanently in contact with an acid solution and are run at speeds of 3,000—7,000 r.p.m.—according to their size. This article has given satisfaction in use over a number of years and is being used to-day by many artificial silk manufacturers in this country, and the Continent and in the United States.

The motor car industry has been using mouldings for many years, in the manufacture of their electrical equipment, but it was not until about three years ago that they realized the value of plastic materials in other connections. Since then, progress has been made by "leaps and bounds" and to-day we find well known manufacturers of motor cars, employing mouldings for window frames, instrument panels, complete dash boards, shelf rails and many other internal body fittings. I am very happy to be able to tell you that I am connected with the company which produced successfully the first mouldedmot or car window frame. This type of moulding is also being manufactured in Germany and I have samples here, which you can see. Considerable research is being made in connection with the motor car industry and I venture to state that we shall shortly see extensive developments in materials and methods of manufacture. These developments I hope, will give to the motor car industry, plastic parts superior to all existing fitments and with qualities which will overcome their difficulties. I cannot as yet visualize in this country, the all-moulded plastic body as produced in Germany. The development in that country, I feel, is more a matter of necessity than choice, but I do think that we can use plastics in some form, in the make up of the body, and I am at the moment spending a great deal of my time in this connection. Progress on this type of development is extremely slow, due to tool costs, but I feel sure that with the help the plastics industry is now receiving from the motor car industry, in the very near future, we shall be able to achieve success. Other parts of a motor car, can be successfully manufactured in plastic materials and I do know of experiments which are being carried out on such articles as : pulley wheels, fan blades, oil sumps, valve rocker covers, and radiator parts. The aircraft industry is investigating its possibilities, and tools are at the moment being manufactured in this country to produce moulded parts in sections, to form aircraft wings. Undoubtedly, if this experiment proves a success, further parts will be manufactured. It will then be necessary for the plastic industry to buy and put down press equipment, considerably greater than any equipment which we now have in this country.

The use of phenols is well known to you in such industries as refrigerators, vacuum cleaners, etc. In point of fact it is difficult to name an industry to-day in which this material does not play a part.

The method of fabrication of phenol materials is known to most of you, the first principle being a good quality steel mould or die of at least two parts, which when fitted together or closed, form a trapped cavity. A slight clearance between the upper and lower part of the mould is essential, to allow for the escape of air or gases in order to guarantee a perfectly homogeneous article. In general practice, when using phenol materials with a fine filler such as wood flour, the semi-positive type of mould has been found to give the best all round results. This type of mould is generally used in the United States, although it is agreed that one is apt to waste a little more material than with the positive type mould.

Materials such as shock resisting materials and other materials having larger forms of filler, usually require a more positive closure, due to the materials inability to flow readily and consequent trapping of the fibres. The curing time necessary to produce a sound article is determined by the type of material and the section which is being moulded, and this time may vary from 1 minute to 10 minutes.

I feel you are all fully conversant with the methods used in the finishing of moulded articles after they have left the mould. In some cases the burr or flash is removed by means of a hand file and in other cases they are removed by grinding. Holes can also be drilled and tapped in the finishing operation of the article. Some manufacturers to-day are drilling and tapping holes in mouldings by means of multiple spindled drilling and tapping fixtures, which as you can appreciate, considerably helps to reduce costs.

Transference Moulding.

The latest practical development in the manufacture of phenol mouldings is that known as transference moulding. This method is sometimes referred to as phenol injection, but it is wiser to use the former term, to avoid confusion with the thermo-plastic materials, which are commonly termed—injection mouldings. The principle of a transference moulding is that instead of placing the raw material in the mould proper, it is first rendered into a liquid or plastic state in an auxiliary cavity and then forced through a hole or grate into the final mould. The advantage of this method over normal compression, is that delicate inserts and internal delicate mould constructions are not damaged by the flow of the material. It is therefore possible to mould fine holes, slots, etc., hitherto impossible, due to the tool form becoming damaged under the normal compression system.

The moulding in of inserts running right through the material and projecting on either side, has become very much simplified, and due to the method of flowing the material, it has been found that the curing times in the case of heavy sections have been considerably reduced compared with the curing times necessary for compression moulding.

Urea Material and Fabrication.

Urea materials are very much akin to phenol materials, the main points of difference being, (a) the basic resin is water-white, compared with the amber colour in phenol, this feature renders possible the production of pastel shades and translucent effects, (b) the colours are much more fast to light and, providing fast dyes are used, fading is negligible, for the resin, being colourless, cannot fade, (c) the filler is usually of paper, although wood filled urea's are available. Recent developments in this class are a shock-resisting urea, and glass-clear urea. Urea materials are favoured from the decorative standpoint and are much more desirable than phenol materials when in contact with food stuffs. Their electrical properties, particularly that of non-tracking, secured for them a wide field in this direction and in the manufacture of ships fittings, the reason for this being that urea materials will stand sea water conditions better than any other known materials. Apart from the glass-clear and shock resisting materials there have been very few recent developments worthy of discussion, except the improvements made in the material to the advantage of the moulders. A few years ago the moulding of urea materials presented much more difficulty than that of phenol, but today, providing care is exercised in mould design, working temperature, and cleanliness, the industry is just as happy with either material.

Perhaps in fairness to the material manufacturer, I should mention the improvement in the speed of cure of urea. The time required by these materials to cure has been gradually reduced and to-day we can produce outputs of 50 cycles per hour on thin sections, such as we find on lamp shades, etc.

The type of mould used when working urea materials can be similar in design to the phenol, but unless one is using a densified form of powder, it is necessary to design the mould with greater depth of filling room. It is also necessary that the mould should either be made from stainless steel, or that the mould after being manufactured should be chromium-plated. As this type of material will stain moulds made from the same type of steel as used on phenol materials. The finishing of articles made from this material is also similar to that of phenol material.

Extrusion of Phenol and Urea Materials.

The extrusion or continuous moulding of rods, tubes and sections up to any desired length, can probably be termed a late development, having a commercial application in materials of the thermo-setting class. By this process tubes and rods can be produced, having no draw along their length and sections incorporating longitudinal undercuts are rendered comparatively simple. The principal employed is to use an open mould with a braking or retarding device to give the desired back pressure, this breaking device coming into action on the finished section immediately before leaving the die. The resultant moulding is clean and highly polished and has a strength 50% in excess of normal compression mouldings. The material is fed into the mould through a hopper, the portion of the tool which receives the material being water-cooled to prevent any "stick-up," at this point. The material is forced along the die by means of a piston or pump. The temperature of the die gradually increases from about 60° C. to 190° C. The cross sectional area of the tool is gradually reduced from a simple form, which embraces the extremes of the required section down to the final size. That portion of the tool which assumes the final form is that which is maintained at the greatest temperature and is where the actual cure takes place. The section finally passes through the braking device and the guides, and emerges ready to be cut off to the desired length.

The speed of production of a 4¾ in. diameter tube is about 5 in. per minute. A 1 in. diameter tube can be extruded at the rate of about 12 ins. per minute. The speed of extrusion is dependent upon pressure, speed of cure and frictional resistance. No doubt in the course of time improved materials will be developed, which will enable extrusion to be made at much higher speeds.

Acetate Materials.

Having dealt with the main materials in the thermo-setting class, I now arrive at the other major branch, the thermo-plastic materials, of which cellulose acetate is the best known and most commonly used. This material, unlike the thermo-setting type, softens when heated and hardens off again when chilled. No chemical change takes place in the moulding operations and in consequence the material can be re-worked after moulding, thereby reducing waste to a minimum.

The method of fabrication is very similar to that of die casting, the material being heated in a cylinder and then squirted or forced into a closed mould, through a narrow gap or gate, with a pressure of between 7 to 10 tons per square inch. Contact with the mould which in some cases is water circulated to keep it cool, hardens or

freezes the material. There is no cure time as in the case of thermo-setting materials. The length of the cycle is therefore only dependent on the time taken to close and open the mould, to eject the article and the time required for the material to flow into the furthermost parts of the mould. Until recently only small articles could be injected, the reason being that the material hardens-off when entering the die, therefore restricting the length of flow. To-day, however, there are a number of firms in this industry who are doing a great number of multiple injection mouldings, and in this way using the full capacity of their injection machines. Machines are now being manufactured in America, incorporating multiple cylinders perfectly syncronized in action, these machines having a moulding capacity of 32 ozs. With this type of machine one can manufacture such articles as steering wheels, glove box covers, and window frame mouldings. The method of manufacturing the steering wheel is to inject or cover a rough metal casting with cellulose acetate. In the case of the glove compartment cover, only the external side of the metal is covered.

There are two major reasons for the use of metal. One is that by this method the strength of the metal can be utilized, having a cover which is both beautiful and pleasant to the touch and, what is more, a finish which is permanent. The other reason is one of cost, acetate is more expensive than metal, which is used for the core and it therefore becomes a cheaper proposition to cover a cheap casting than to make a solid plastic job. A further consideration is that the greater the quantity of material you inject the larger and more expensive the plant required. The cellulose acetate window frame is of thin section, having no metal core. Its flexibility makes it admirably suitable for this application, as once fitted into position it will flex or give should the car body or doors temporarily distort under strain or unfair usage.

The development of injection moulding has considerably widened the use of plastics. Due to their flexibility it is possible to make a sound joint by the use of a simple solution like acetone, mouldings can be made in several parts and then joined together, rendering possible shapes which are impracticable in the thermo-setting materials.

Cellulose acetate mouldings can be obtained in all colours, translucent and opaque, and also in glass-clear. Apart from the cellulose acetate materials there are other types of materials suitable for injection moulding. The better known are aerylie and polystynol compounds. These materials are worked in the same manner as cellulose acetate, but have the disadvantage of a lower softening point, are not as strong and are more expensive. The main advantage of these materials, is their resistance to acid and alcoholics, good electrical properties, and remarkable clarity, the last named

property having found them a wide field in the optical market.

The application of injection mouldings is limited to a certain extent by their low softening point. Some manufacturers claim as a softening point as high as 176° F. to 194°F., but it is wiser to assume a temperature of 140° F. This figure, particularly when quoted at 60° C. often alarms the would-be consumer of thermo-plastic materials, but a little reflection reveals that an exceedingly small proportion of articles are required to withstand this temperature. One of the major advantages of injection to impression mouldings, is the low tool cost necessary to cope with large outputs. As I have previously mentioned, there is no cure time with the injection method.

On certain articles, outputs from a single impression injection tool using cellulose acetates have exceeded that of a twelve impression compression mould, using phenol material. It can readily be seen that where large outputs are required, injection methods have a great advantage, due to the low initial cost of the dies. This is an important factor, as heavy tool costs have lost the industry many a good customer in the past.

I must not leave the subject of injection moulding without mentioning an application which is evoking considerable interest in this country, that of frame moulded around a sheet of glass. The glass is used as an insert in the tool, the material injected round its periphery and the resultant article is the glass firmly framed in a strong surround. This method of framing glass has the great advantage that it obviates the necessity for rubber or cork gaskets on such articles as instruments, etc.

If only by virtue of solving many of the problems which beset the plastics industry, thermo-plastic materials have established themselves on a sound footing and are destined to play an even more important part in the future. The change over from phenolic to acetate material on the Post Office telephone cradle, is one instance where its adoption has eliminated breakages. Due to their limitations, injection materials will not replace their older brothers, the phenols and ureas, but they are firmly established and can be regarded as yet another addition to an ever growing choice. Some day, the fortune that awaits whoever can combine the advantages of all these materials may be acquired, but until then we must consider ourselves fortunate in having such a wide range from which to choose.

Sheet Materials.

The process of impregnating paper or cloth by passing over continuous rolls through resin baths is not by any means new, but you may not all be aware of the photostatic method of surfacing the sheets which are made from paper and cloth. No doubt you are

conversant with the method of pressing plastic sheet or board, that of taking the impregnated material, varying the number of layers to give the required thickness and pressing between thin chromium plated sheets in a multiple daylight press. It is now possible to obtain perfect imitations of any desired finish, by using a photographic process on the outer layer. Printing or pictures suitable for advertisement or notices may be incorporated with sheet material and, due to the print being covered with a skin of clear hard resin, permanence is assured.

A method of overcoming damage to the surface of sheet material, when used for such articles as table tops, where hot dishes, etc., may be in direct contact, is to mould a sheet of thin metal foil just beneath the surface. As you know, all plastics are poor conductors of heat, and the metal foil serves as a conductor and distributes the heat over the entire surface, thus avoiding marking or loss of gloss, which localized heat would tend to cause.

By the use of thi-urea resin, white, cream and pastel shades may be obtained in sheet form, but care must be exercised in the use of these as this urea, unlike the normal urea resin, tends to yellow slightly when exposed to strong light. The use of sheets of impregnated cloth in specially designed compression moulds is solving many of our strength problems. This application is of course very limited, as the material has very little flow and must be cut to suit the form of the tool. For flat articles, and even for fairly complicated strip sections, collaboration with the customer has resulted in a satisfactory article having very great strength.

A type of material has recently been developed, an impregnated pulp, which possessing a certain amount of movement or flow under heat and pressure, can be moulded up into articles possessing shape and to a certain extent, varying section. Experiments with this material have produced very hopeful results and it is interesting to note that the inherent brittleness of plastics has been overcome, so far as it is possible to drive nails into the finished article with less danger of breakage than has previously been experienced.

Tools.

Speaking as a moulder and disregarding the trials and tribulations of the raw material manufacturers, the most important side of the industry is that which is responsible for the making of the dies. Perfect material, perfect plant and the best possible organisation are useless, unless both the design and the manufacture of the tools are correct.

One of the difficulties of the trade moulder is the high cost of tools. Customers desire plastics, but are loth to pay the price for a really first class tool. Much criticism has been levelled at the industry from the angle of quality. To those who find fault, a gentle reminder,

a fair proportion of plastics are turned out to a price and not to an ideal. Some may say we have made our bed, etc., but the plastics industry is one of fierce competition, which even those with high ideals must meet. There are many schools of thought on tool design, but my own feeling is that each individual job must be treated on its merits, and to lay down hard and fast rules is to attempt the impossible.

For compression mouldings, as I have previously mentioned, the semi-positive type of mould is generally favoured, and a very large proportion of plastic mouldings lend and will continue to lend themselves to this method. The semi-positive tool is perhaps a trifle more wasteful in the flash, or escape of excess, than the positive type. The semi-positive however, has been proved to be easier to manufacture, more adaptable should modifications be found necessary, less liable to wear and produces the best all round mouldings. Certain designs, however, are more suited to the positive and flash type and in many instances a combination of two types may be found to be the ideal. With regard to injection moulding, I am of the opinion that we have all a great deal to learn about tool design. Sizes of stalk, gates and point of entry are still debatable points, but it is worthy of note that despite varied opinions, I have seen excellent results produced from every plant I have had the good fortune to visit.

Plant.

The engineering and machine tool industry has shown intense interest in the last two or three years, in the equipment necessary for high speed production of plastics, which has resulted in many noteworthy developments. Chief amongst these are the automatic injection machines, the Lauterbach machine, the Stokes automatic moulding press and high speed pelleting machines.

It is regrettable, that while the normal purpose hydraulic press of British manufacture is equal to any, we have to look further afield for special machinery. This is understandable, due to the comparatively short runs on any one article in this country, compared with what we find on the Continent and in the United States. The sale in this country of automatic injection machines is rapidly increasing, and I hope to see in the near future British machines comparable with American and Continental models. To work a battery of injection machines, the usual practice is to have a female operator to feed the hopper, the same operator having, in the case of tools with only a small number of impressions, time to examine and rough clip or trim the mouldings as they are ejected from the machines. With this method one male fitter to a number of machines is all that is required.

The Lauterbach machine of American origin, is a rotary auto-

matic moulding machine for compression moulding. There is a single hopper and the moulds twenty in number, rotate on a circular table and are charged with powder as they pass under the hopper. During the course of rotation the cure takes place and the mouldings are automatically ejected after having travelled the complete circle, immediately before the mould receives its next charge. With these machines, if carefully adjusted, one operator can control a battery of six to twelve.

The Stokes automatic moulding press is designed for single impression moulds, of a larger type than it is possible to use on the Lauterbach. This machine is electrically controlled and in effect reproduces automatically the complete cycle of operations employed by an operator on a normal compression press. It is remarkably efficient and here again one operator is capable of taking charge of a number of machines.

Considerable improvements have been made in the design of Pelleting machines. Much favour is now given to the rotary type, which is doubtless the most efficient method of pelleting. The chief advantage of the rotary type over the single acting, is that more time is allowed for the manufacture of each pellet, resulting in a more reliable job. It is of course necessary to have a number of tools in the rotary machines, against a single bolster in the single acting, but from the view point of accuracy in weight and consistency in hardness, there is no doubt as to which gives the best pellet.

I realize that I have not strictly adhered to the title, but as I stated in my opening remarks, recent papers read before this Institution had considerably narrowed down my scope. I have, however, endeavoured to compile as much interesting data as possible, without forcing on you that which had already been expounded by previous speakers.

To those who were not fortunate enough to hear all the previous lectures, I tender my apologies, if my explanations have not conveyed fully that which was intended. However, there is still ample opportunity for me to enlarge on any points which are not perfectly clear, and therefore I propose to leave the remainder of the evening to our combined efforts.

Discussion.

MR. KIPPING: Mr. Snell's review of recent advances in the plastics industry will, I know, have been of great interest to everybody. As production engineers, possibly more of us are users of plastic materials than actual moulders of them, particularly of such materials as bakelite sheet, which is very common throughout the industry. However, there are a few questions which are always topical.

One thing which it is always interesting to know is what to-day are the limits of accuracy which the moulder can obtain. In my own industry—the telephone industry—large users of mouldings of pieces which are going to be assembled into bigger units, questions of beautiful finish seldom arise except on the thing that everybody knows about—the hand telephone set, and I do not think that can be held up as an ideal of beauty; but in sub-assemblies one knows oneself the difficulty that occurs with this eternal question of the limits of accuracy which can be met. Many of the difficulties, I have no doubt, are due to the lack of familiarity of the people who have designed apparatus and instruments for the requirements of the plastics industry, and with just those little tricks which would help to obtain more accuracy; so I would ask Mr. Snell if he would bring us up to date on that point.

I do not know, too, whether it would be outside the scope of the paper to ask to be brought up to date with any information he may have on methods of cutting such materials as bakelite which still offer difficulties. I include blanking in that, of course, besides cutting with milling cutters and drills.

Finally, one small point occurred to me that might be of interest in connection with the removal of flash from mouldings. In the case of a mass production job like the telephone hand-set—I speak particularly of the American model—the profile flash which occurs in the middle of the handle is removed by means of a special purpose profile milling machine. The milling cutter is very minute, of course—only about a 2-inch diameter, even less I think—and the machine is arranged with a table which carries the hand-set through the correct profile so that the cutter goes right round the flash and gives actually a tiny recess all round the handle which improves the appearance. That may or may not be familiar to you. Perhaps you have other interesting examples of that, Mr. Snell?

MR. SNELL: In reply to our Chairman's first point regarding moulding accuracy, from the moulder's point of view and as moulders we feel that in the past we have been claiming too great an

accuracy for mouldings. We have difficulty with the variation in materials, and also due to the construction of the mould you might get very great variation in the article that that mould produces, and we do feel that greater tolerances should be given and greater tolerances can be given in the designing of the moulded article. We do not feel that we can go any closer than we have been telling people we can do in the future—not to give a satisfactory job and to make the job satisfactory from the moulding point of view.

Our Chairman's second point was the cutting of bakelite sheet. I think possibly Mr. Last, who is with us this evening, is in a better position to give us some up-to-date information on that, and I would like to leave that to Mr. Last if I may.

With regard to the third point on removing flash, and specially removing flash on the telephone instruments, I was fortunate when I was in the States to see the most up-to-date method of manufacturing the telephone hand-set, and I have noted that in their moulding operations, which covered a considerable time—a matter of two or three years—they have had three tries to produce the telephone set under really ideal mass production: and their latest moulding machine takes a very big mould, and they just place the material into the mould, touch the button, and the machine does the rest. Also, as our Chairman states, they remove the flash by machining a very small groove round the flash line of the hand-set. I do not feel that we general moulders in this country can tackle the general mouldings which we have to do in the same perfect manner.

MR. LAST: Mr. Snell in this paper made mention of the fact that the electrical industry was the first to grasp the possibilities of the phenolic moulded plastics. In this I entirely agree with him, and I will go further and say that even at the present time the electrial industry is stiill the largest consumer, so far as our statistics tell us, of phenolic plastics.

The industry in the past, and even to some extent to-day, has suffered and is suffering from the over-enthusiasm of people like myself and like Mr. Snell, connected with the productions. There was a period some years ago when people used to talk of phenolic plastics as being unbreakable, and that did the industry quite a lot of harm. In point of fact it is very necessary to know the limitations of all these plastic products before you can begin to think about their advantages, and in this connection, as Mr. Snell indicated, the industry has gone to a great deal of trouble to develop the so-called special materials—shock resisting materials, heat resisting materials and so on; and whereas the average moulder in the old days used to think in terms of the standard wood-filled type of material only, he now is beginning to find out which is the most suitable material for the job he has got in mind, without jumping to the conclusion that he can use standard materials on every job.

In connection with Mr. Snell's remarks on urea materials, I think I am right in saying that he mentioned that they have definite advantages from the non-tacking point of view over electrical accesssories made in other materials. In my opinion this advantage is rather outweighed by the fact that the water absorption of urea materials generally is about five times greater than that of the phenolic class of material, and this is the one point on which I want to cross swords with Mr. Snell. I think he said that urea materials had been proved to be the most suitable type when in contact with, or exposed, to sea water. I would like confirmation of that from Mr. Snell. I can quite understand they would be the most suitable type when exposed to sunlight, because of their permanence of colour, but I would like confirmation if they are the most suitable type when exposed to sea water and sea atmosphere.

In connection with tool design, this of course, as Mr. Snell pointed out, is one very important part of the industry, and unfortunately the industry is suffering from an acute lack of craftsmen in the tool-making side. There does not seem to be any proper schooling or training for plastic tool makers, and although the Institute of the Plastics Industry has been trying to do something in that connection it might be something for the Institution of Production Engineers to bear in mind—the acute shortage of tool-makers in our industry.

Of course we realise that accurate tool design and tool-making represents about 90 per cent of the success of any moulding job, but if you go beyond that you have got to give credit to the ingenuity of the research chemist who first of all develops the materials. In Germany the development of synthetic and substitute materials has gone a lot further than it has in this country, owing to the fact that they must conserve all the metals they can for ammunition purposes. Their development of plastic materials has been on a much larger scale than in this country. The plastics industry had its foundation in the work of an early research chemist, Dr. Bakerman, who really put the industry on the map thirty years ago, and in this connection it may be interesting to quote some statistics that I have noticed recently, that in 1913 the annual world output of plastics was 50,000 tons, and in 1938 the annual world output was 500,000 tons ; so some progress has been made in the industry.

Finally, I would like to emphasise that the plastics industry has all the research chemists it requires, and all the salesmen, the publicity experts, industrial artists, and all those people who batten on to a new industry, but what we do want more than anything else is more up-to-date and experienced production engineers.

MR. SNELL: I think there is just one point, Mr. Last, which you wish me to reply to, and that is with regard to urea materials in connection with plastics. We have carried out tests with ship's

fittings in various materials, and in every case we have found that urea materials do stand sea water conditions better than phenolic materials, and I think you will find they use more urea materials for ship's fittings than any other material that has been manufactured.

MR. J. MCFARLANE: From an expert in plastic materials to the most ignorant man in the room is a big step, but Mr. Snell in the course of his remarks briefly mentioned a German car. I was rather interested in this, and I would like to know if the whole of the body is moulded in that particular car. I do not know it at all. I have heard about it, of course, and of the plastic material that is used: I have heard all the various names you have called it, and I have heard it called other names, but I won't mention those. In addition, I would like to know if the colour in the moulded body is uniform and permanent. That, of course, in all car finishing is of extreme importance, and I think that since the Germans have now turned to moulding the body it will not be very long before motor car engineers throughout the world are turning their attention in that direction, and I do not think it is being optimistic to say that during the next four or five years we will see development of the moulded plastic body in the motor car industry. There is just another little point with regard to the finish, and that is, I would like to know if one uses this moulded plastic body how it will stand up to the ordinary, should I say, scratch erosion which any car gets during its lifetime of two or three years.

MR. SNELL: As regards the moulded car body, I saw this job in Germany twelve months ago, and the body is made up of sections. Each moulding has a right and left-hand section, and on the surface of the sections they have thrown up bosses for the purpose of putting together. The material used so far is a cotton filled material, and the finish is done by painting after the mouldings are assembled together. We have very carefully looked through this and followed the lines that the German people have adopted on the moulded body, but we do not think we have yet a material that will stand up to the conditions that the steel body will do. We are carrying out experiments with moulding the interior part of the body, and still maintaining the exterior steel frame, which on the face of it looks a better proposition, because we understand two-thirds of the cost of the body is in the interior make-up, and one-third of the cost is in the exterior, so we have gone for the interior, and we have moulded the frames and then put an outside coating of steel to take the blow and the knocking about. As regards the scratching of the surface, well, when the material is painted exactly the same as steel is painted then it applies the same to both.

A further development on the plastic body in Germany is that of moulding the body in one operation, that is by using two sections,

two moulded sections of material, and then putting these pieces and a filler between the two materials, and then putting them into a master mould and moulding them as one job.

A MEMBER: When I was last listening to a lecture on plastics a table was mentioned which contained details of stresses and other information regarding plastics. I do not know whether this table is now available, but it was not then, and it would be rather interesting to know the Brinnell stress or something like that.

MR. SNELL: Regarding specifications of materials, I think I am right in saying that Bakelite Limited have now completed their forms of specification, and you can get various tests—tensile tests, impact tests—on all known materials of their manufacture.

MR. BAMFORD: The lecturer mentioned that experiments had been carried out for inserting glass in plastic materials to take the place of rubber sheets, which allowed for a slight expansion of say 10 thou. Could he give us a little more information on that, please?

Another point I would like to put is, what is the best method of curing—by electricity, steam or gas? You also mentioned about the process of tubes, and I was wondering whether it was possible to make tubes by getting a sheet of brown paper and spreading it, putting some plastic material through rollers, and then, say, centrally splining it.

MR. SNELL: As regards your first point, that glass is in an acetate moulding. I have one or two samples here to illustrate that. This is a very satisfactory job. The glass is an insert of the acetate material which has been moulded round. I would like you to know that with acetate materials a little more flexibility is given than with phenolic material. If you have a phenolic material it may crack, due to the contraction of the material to the glass. With the acetate it makes a very satisfactory job. You will find that they are definitely very firm.

Now, regarding tubes and sections, that is a case of the extrusion of material. When you come to sections it would be almost impossible for any form of laminated materials. There are tubes and also rods made from these materials, but it is a rather more expensive process than the extrusion of materials.

I think the cheapest method of heating presses is undoubtedly steam. The electric method has advantages, because by electric heating you can treat your plant and each individual piece of the plant as a unit, and you can work one piece without running the cost of heating all the other parts, but it is definitely more costly. I prefer steam heated, because when you have got a factory that is producing materials, phenolic and urea materials, you want less heat, and you can regulate it very much more accurately with steam than with electricity. I agree that in Germany they use quite a

lot of electric heating, but I think it is the general method in this country to use steam.

MR. COOTE: Regarding synthetic bearings for rolling mills, I have had experience with a synthetic bearing breaking down. We used a certain type of graphite synthetic bearing to start with and it was not satisfactory. We were told that all you need do was just pour some water on the nuts and the bearings would stand up for ever. We started and to our cost we found that that was not the case. We found we had to put an enormous amount of solluble oil on to the bearings to get them to stand up at all, although we have now proved that synthetic bearings will stand up with solluble oil. I have, however, been in touch with some of the oil people and they tell me that in Germany now they are using a grease together with water. In other words, they apply the grease first and then pour on water. I should like also to mention that we are using cloth now as an insert in the synthetic material, and it follows the contour of the roll neck. Is it possible to get a block of bakelite or synthetic material and machine it up to use as a bearing?

MR. SNELL: With regard to the bearing material, my company have just purchased the rights of manufacturing in this country of a special material. This material is made up of synthetic resins and of a filler of metal that actually can be pressed on cast iron. It is moulded as a cold moulding and during the baking the material expands and the pores of the material open and then it is impregnated with oil That is I understand a very satisfactory material, and the tests we have carried out so far have been very encouraging.

In Germany they use a lot of fabric materials for bearings, soft or lead bearings, and they also do in this country. But in the first case they mould the bearings so as to get the strands of the material flowing in the correct direction of the bearing. That is, if you have a bearing of a certain form you would mould the laminations, so that instead of machining across the lamination you would machine to the laminations. I understand from reports that you can run these bearings with water, and I would suggest that possibly you may have got hold of the wrong material when you found that it was impossible to do that. You can buy blocks of bakelite material which you can machine up into bearings, gear wheels, and all such types of jobs, and I would suggest that your best people would be Bakelite, Ltd. who do special material for that purpose. I think if you put your point to them they would give you the best advice and tell you the ideal materials for the job.

MR. NORBURN: It is quite obvious that the cost of the moulding tools is one of the most important points in the industry, and I would like especially to refer to injection moulding. On ordinary bakelite tools one usually uses a cast steel which is hardened. It is quite expensive to machine it out, harden it and then re-polish it,

and on the injection side I have known cases where they get very successful results by using ordinary steel moulds. Therefore, I would like to get some idea of what quantity you can expect from a soft mould, a steel mould, against brass, and also against the cast steel mould and a cast steel mould hardened. Is it practical and can you get a quantity of, shall we say, 10,000 off a soft mould, a steel mould? Obviously there is no pressure on an injection mould in comparison with an ordinary mould, and that is an important point in tool making, where you are trying to get the price down. It would be interesting to find out what you can expect.

MR. SNELL: As regards moulds made from soft materials, we in the industry have made moulds from mild steel for phenolic moulds, but there is a certain amount of doubt about it, and to say that a mould will produce 1,000 or 5,000 articles is difficult. We always feel that even if a mould is working satisfactorily, if it is made out of an inferior steel there is a possibility that that mould may go down and fail you when your customer is pushing you very hard for production. Therefore, there is that big doubt, and that doubt can be very costly. In my opinion—and I have had a lot of experience of mould design and mould manufacture—I think it better to make the moulds, specially for phenolic materials, out of a fairly good quality steel. We manufacture moulds, and specially our big moulds, out of air-hardened steel. It is not too costly. I think you can buy it for about 8d. to 9d. a lb., according to the size of blank that you are using. It is fairly readily machined. You can harden it. It is fairly cheap to harden, and it does not distort during the hardening process. It has a Brinnell of something like 380 to 420, and although it is not dead hard it has a very strong and lasting wearing surface.

As regards cheap cost iron moulds, we have tried cast iron moulds. We have tried meehanite iron, which is a cast iron which can be hardened after the mould is finished, but still there is a doubt there. As you know, it takes you possibly two to three months to make a mould, and you do not want that to go west just when your customer is expecting a prompt delivery. It is risky, and the risk is against the mould. If we as moulders could go to our customers and say, "We will use that material if you can be responsible for the consequences," well then we should do it and be happy to do it. As regards mild steel and the other metal moulds for injections, there is a certain amount of wear on an injection mould. It is not actually in the cavity, but it is in the gates and the floods of those gates where there is a considerable amount of wear. It is a frictional wear and it will very readily wear a soft tool. There is still a doubt which we try to obviate if possible.

MR. NORBURN: Excuse me, sir, we actually use these moulds. We do quite a lot of work and we know that it is very often critical

cases they cannot get satisfaction from the trade moulders, the reason being that they have to face so much competition that they are just cut to death, and the consequence is that when the trade moulder does get a job he is forced to under-cure it. I am talking now from seventeen to eighteen years' experience. If the moulding is cured properly there is very little fault to find with it, providing that the moulder does realise before he starts moulding the exact type of material he needs. Very few people take that into consideration. They are told by the customer what it is they want, and so long as they produce what appears to be a good mould they feel quite happy about it, and when the mould falls down they are very dissatisfied with the material. I am sure Mr. Snell, as a trade moulder, will agree with me that it is the tremendous amount of price cutting in the trade which does not really give the people a chance to supply a properly cured mould.

There was another point if I might return to the subject of our Chairman's remarks about limits in moulding. I would be very interested to hear what he considers as feasible limits for mass assembled mouldings. In the company with which I have the pleasure of working we do somewhere round about 80,000 mouldings a week, which is all mass-produced stuff, and on the majority of these mouldings we can get from two to three thou. limits, and I do think that with proper control in the works even though one does get variations in moulding, one should be able to overcome the slight variations. I also think that proper design of shrinking jigs and so on should quite readily give you three thou. accuracy on mass-production jobs. If the job is really designed correctly I think they should go together without a great deal of difficulty.

MR. SNELL: I agree with the speaker regarding price cutting, although my company has not been responsible for it. I agree that it has been due to the price cutting that possibly we as general moulders have not been able to turn out our ideals. I agree that we have to under-cure mouldings to get them out at the price, but the point is if we did not do it the other fellow would do the same thing.

As regards accuracy, I think if the speaker is working to a limit of even plus or minus three thou. he is doing exceptionally well. My company is not working to that accuracy, and we are turning out possibly 20 to 25 tons of mouldings per week, but we are not up to that standard yet. Perhaps our chairman would like to comment as he first raised the point of accuracy.

CHAIRMAN: I would like to say that that is one of the limitations in the use of plastic mouldings in the electrical industry, the inability to maintain about two or three thou. and in some cases less. Notably, of course, there is a case in which $1\frac{1}{2}$ thou. is consistently held, and that is in the thickness of thin bakelite sheets.

MR. LAST: This is a moulding made of a special phenolic material. Now that is an artificial silk spinning pot, and this pot. here is immersed in acid, and also is washed continually while it is running by water on the outside. This will absorb moisture and it will continue to grow all the time it is absorbing that moisture, but the construction of the pot is so designed that the growing of the pot does not allow it to burst. This pot is in use for about three to four years before it bursts, but eventually it will, due to this water absorption. You cannot avoid that. There are special phenolic materials on the market with very low points of water absorption.

As regards urea materials, I think the modern material has a very much lower water absorption than the usual material, but I cannot give you any actual figures, because I think it would be very difficult as it is all tied up in the design of the job. One design possibly would absorb more moisture than another. Of course if you break the skin of a moulding, whether it is phenolic or urea, the material will absorb more moisture than it would if the skin was intact.

CHAIRMAN: If I may be given the privilege of a second question, I should like to ask Mr. Snell to make a comment on a rather different side of the subject, and that is to tell us why he thinks moulding work should go to the general moulder and not be undertaken by the individual manufacturer. So many individual manufacturers these days do put down their own small moulding plants. They believe presumably that the concentrated attention they would give to their own particular problems and the special conditions required justify them in doing so, and I would just like to hear a few remarks on this.

MR. SNELL: I feel that we can manufacture mouldings cheaper than a proprietary moulder, because a proprietary moulder is manufacturing his own lines, and he has possibly only got one or two lines, and if they fall short or slack, then he has got to leave a certain amount of his plant idle. Where we, as general moulders, may have 100 or 200 customers, and where one falls down the other one naturally comes up. Therefore our customers do not suffer due to this. We feel that as general moulders, coming across a great variety of articles, we have more knowledge of the business and we are in a better position to produce a far better quality of article than the proprietary moulder could produce himself.

MR. JENNINGS: I do not know whether it is out of order for me to speak, because I am not a member of the Institute, but I did not feel I could let the opportunity pass of replying to Mr. Snell on the question of being able to produce mouldings cheaper than the consumer moulder, which is possibly the case owing to competition, but I think the majority of conusmer moulders do set out with the idea of doing their own mouldings.

I may say I am trying to get the cost of the tool down. Although you say it wears in the gates, the wear is not actually in the job itself. One can always weld a piece of the gate. With cast steel it is very expensive to harden the job. It is a question of moving on these non-moving steels, and then you have got to re-polish the job. Could you get a good quantity off a cast steel and still leave it soft? Could you get 20,000 off it in an injection?

MR. SNELL: With a good quality steel, say G.I., yes you could. I would like to come back to this mild steel mould. I have given close consideration to the cost of a mild steel mould against a hardened steel, and the cost of the air-hardened steel is about 8d. to 9d. a lb. It machines very readily and the cost of hardening it is about 3d. a lb. On the other hand if you take a good quality mild steel you have got to pay 5d. a lb. and the cost of case-hardening is about 5d. a lb., so really the actual outlay when it is finished is about the same. You have certain conditions in the machining of the mild steel where it is easier to machine, but then on the other hand the case-hardened steel is easier to get a finish on, and the finish is more permanent and bright and the closeness of the grain is a big advantage in the moulding of an injection or phenolic material, so I do not think really you gain a lot.

MR. HOLLOWAY: I was very interested in some of the remarks made by Mr. Last regarding the water absorption of urea materials as compared with the phenolic materials. I think I heard Mr. Last say the urea materials absorbed something like five times the amount of water compared with the phenolic materials. I wondered whether Mr. Snell would give any figures at all regarding dimensional changes due to water absorption in the two types of material, that is the phenolic material as compared with the urea material; and also whether you have any information regarding direction of water absorption, the direction in relation to water absorption and dimensional changes. Also could you give any figures at all regarding water absorption on the moulded skin as compared with machined skin? Again, if you have any information or figures regarding dimensional changes due to water absorption on shock resisting material I should be glad to have it.

MR. SNELL: As regards the water absorption of urea materials and phenolic materials, it is greater with urea materials than it is on phenolic materials. The action of water absorption on urea materials is more drastic. If you get thick sections of urea material and they continue to absorb moisture then you will get cracking, especially if the thick section is slightly under-cured the moulding will burst, but there are different conditions that effect the moulding. A moulding possibly will absorb moisture for a period and then for another period it begins to dry out again, so really it does not get to the point where it is continually absorbing.

MR. NORBURN raised a question about the making of injection mouldings to close limits and the use of mass production methods for the purpose.

MR. SNELL: We do manufacture mouldings to close limits, possibly plus or minus 1½ thou., but we cannot manufacture these articles by the mass production method. We can manufacture, but we do not like to, and in the majority of cases we do not think it is necessary. It may be necessary in a few minor cases, but as you know, when a drawing is prepared in a drawing office, the draughtsmen put the limits, and no doubt they could expand the limits considerably, and we do feel we are able to manufacture articles at close limits. You will, of course, find a job where it is necessary to have a close limit, but it is not necessary to have close limits on everything.

You can take quite a number of mouldings which we manufacture and which have been manufactured by the trade for the Air Ministry. If you take the limits that the Air Ministry have called for on some of their particular work it is really ridiculous, because it is not necessary, and to attain these limits, as you know, the tool has got to be manufactured and costs 50% more. You have to have very close inspection of the job, and it makes it much more costly. I do not know if there is anybody here who is manufacturing Air Ministry work, but I think this work costs possibly three or four times what the ordinary general work is costing and it is only due to the close limits which possibly are not necessary.

MR. BATE: A previous speaker asked a question on fabric and you stated that they bake these roll neck bearings. Do I understand that they build them up in the lamination, or do they take them in the same cooked condition and bake them and set them? I think you said they make them in a fabric and build up section by section, or is it taken in the same cooked condition, baked and set?

MR. SNELL: The laminations are impregnated in the same manner as you would make laminated sheet, and then it is moulded into that form, and during the moulding operation it is cured at the same time; so whereas in a sheet you get your laminations running parallel, the laminations are still running parallel, but they are taking the form of the bearing.

MR. BATE: It will come in each layer separately?

MR. SNELL: It is done in the same way as if you are making sheet material, where the sheets are laid one on top of the other, and mounted up to its thickness, and it is then put in the mould in the form of a bearing and pressed, so that the laminations are running to the form of the mould.

MR. BASTABLE: Following on the remarks you have just made, we have been working on experiments on wing parts, and I should like to know what would be a possible material to use, whether it

should have a cotton or fabric base or a felt base. Do you use much felt? The next point is, what is the effect of the large vibration on the wings on plastic mouldings? I should also like to know the effect of a bullet on the wing of a machine. When a bullet hits an ordinary metal wing it makes a large puncture and probably takes quite a large piece of metal away. Would you get the same effect if you had bakelite mouldings, and would the raw edges exposed to the air tear very badly once you had broken the continuity of the surface?

The next thing, with regard to aircraft, how would you get over the cost of making castings? The first casting may be unique, the second a little different, the third more so, and perhaps the fourth might be different again. Is there a fairly cheap method of moulding the machine? I know bakelite Ltd. have got a substance, a mould which has been used two or three times. Can you get a job which you can recommend?

MR. SNELL: The material we have used in our experiments on aircraft wings is a fabric material, an impregnated fabric material, and due to the various thicknesses that are demanded this material has to be cut into various strips and laid on to a form, so that in moulding the article you do not displace the fibres of the material at all. We do not know yet whether it is going to be satisfactory. We have made test pieces and have carried out experiments on these test pieces, and they have so far proved satisfactory.

I do not just know regarding the effect of material being displaced by large forces, and I should think it would behave better than metal. Possibly a bullet would punch a hole through the material quite readily, but it would not throw up a tremendous great flange like metal. There are no raw edges on the material, and the edges of the material after they have been in the mould have very good finishes, because the resin in the fabric goes to the surface and gives a smooth appearance.

With regard to the accuracy of the mouldings, taking a moulding about 3 ft. by 2 ft. 6 in., I should say we could work to a limit possibly plus or minus $^1/_{32}$ in., which I think is very good for that size of mould when you consider that the material shrinks possibly 7 thou. per in. By the method that we are manufacturing these jobs the tools are costly, because we have got to get such a tremendous amount of pressure on to the material to get a sound job; and if you take aircraft construction, if you look at aircraft design, you will find that it is a thing where you cannot just take a piece of sheet metal and bind it over forms to get a decent job.

The meeting concluded with a vote of thanks to Mr. Snell.